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Developing Entrepreneurism: Student Training and Involvement

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Developing Entrepreneurism: *Student Training and Involvement*

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Sorghum Food Enterprise and Technology Development in Southern Africa Workshop
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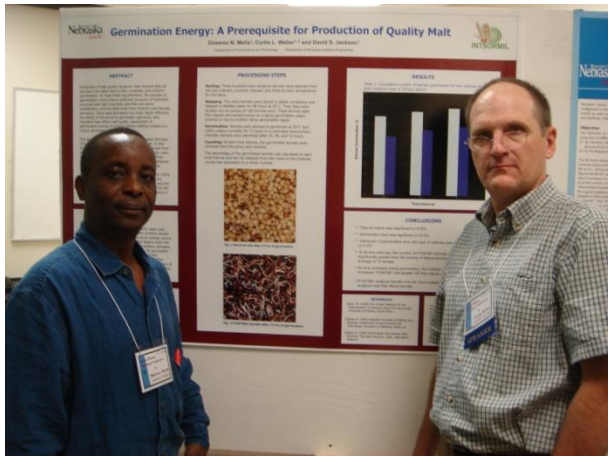
University of Nebraska Lincoln

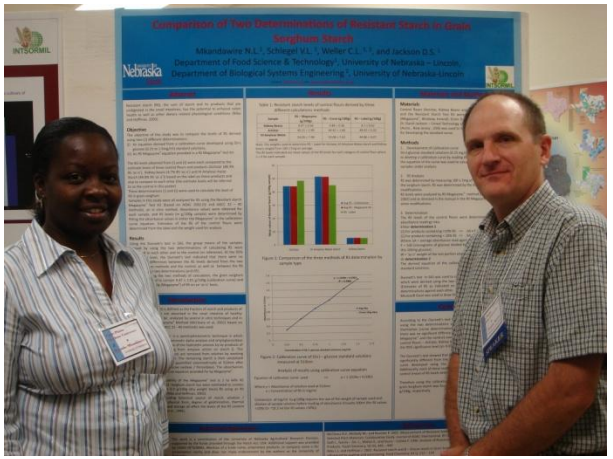
Objectives

- Student training is an important component of INTSORMIL UNL-SUA-UNZA project
- Current students and their backgrounds
  - Onesmo Mella is a Researcher with the Tanzania Food and Nutrition Centre in the Ministry of Health and Social Welfare working on his MS degree
  - Nyambe Mkandawire is a Lecturer with the University of Zambia Department of Food Science and Technology working on her PhD degree

Current Projects

- Summary of progress for current projects
  - Effects of malting and fermentation pretreatments on properties of grain sorghum flour and sorghum-containing products (OM)
  - Starch and fiber digestibility for tannin-containing grain sorghums (NM)
  - Digestibility of pure isolated starches (NM)





Measurement of Starch Digestibility in Starch and Flour from Tannin containing Sorghum

Mkandawire N.L., Weller C.L., Rose D. J., and Jackson D.S.

Grain Sorghum

- *Sorghum bicolor* (L.) Moench
- 5th most important grain
- Important as a feed grain (US) and food (Asia and Africa)
- Low digestibility
- Classified* as
  - Sorghum
  - Tannin Sorghum
  - White sorghum
  - Mixed sorghum

*FGIS – GIPSA, 2008

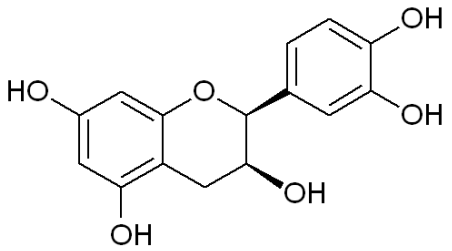
Tannin sorghum

- Some sorghums have a pigmented testa
- Condensed tannins – present in inner integument of kernel
- Reported levels of condensed tannins in sorghum - 68 mg catechin equivalent (CE) / g

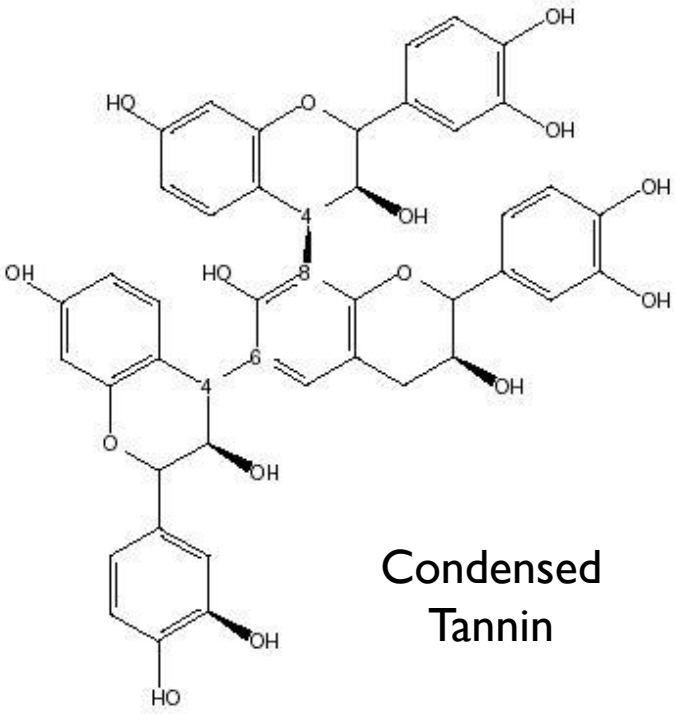
Awika and Rooney, 2004

Condensed Tannins

- Proanthocyanidins, procyanidins (syn.)
- Polymerized flavan-3-ol and or flavan – 3,4 – diol
- C4-C8 and C4-C6 interflavan bonds
- Polymer units
  - Catechin – terminal units
  - Epicatechin – extension units
- High molecular weights with variable lengths



Catechin



Condensed Tannin

Importance of CTs

- **Tannins complex with macromolecules : Proteins, polysaccharides, minerals,**
- **Reduction of digestibility (Proteins and others)**

BUT

- **Excellent *in vitro* antioxidant properties**
- **Low digestibility – good for humans**

Awika et al, 2003; Dykes and Rooney, 2006;

Relationship of CTs to Polysaccharides

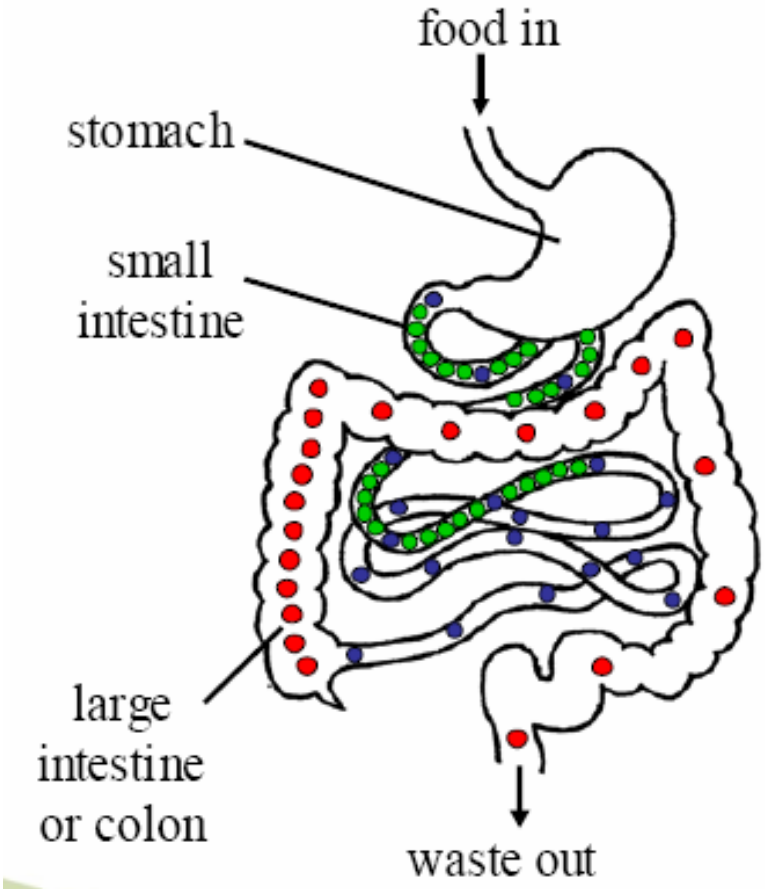
- **Tannins + Proteins (also enzymes) → reduced protein and starch digestibility**

- **Some polysaccharides prevent protein – tannin interaction →Xanthan, Pectin, gum arabic, carragenaans**
- **But not carob, guar and tara gums**

- **Tannins reported to complex proteins, carbohydrates / polysaccharides, minerals, alkanoids etc → reduced digestibility**

Awika and Rooney, 2004; de Freitas et al, 2003; Carvalho et al, 2006

In vivo digestion



Digested – Rapidly

Digested - Slowly

Resistant to digestion

Rate of digestion of Starch in humans

In vitro digestion

- According to Englyst et al, 1992
- Rapidly digested starch (RDS)
  - Amount of glucose released after 20 minutes
- Slowly digestible starch (SDS)
  - Amount of glucose released between 20 and 120 minutes
- Resistant starch
  - Glucose left after 120 minutes
  - RS = Total Starch – (RDS + SDS)

Table 1. Resistant starch types, definitions and examples

Resistant Starch Type	Definition	Example
1	Physically inaccessible *(e.g., surrounded by plant cell wall material)*	Coarsely ground wheat
2	High amylose *(long chains, little branching)*	High amylose corn starch
3	Retrograded amylose *(long chain double helices)*	Cooked and cooled potato starch
4	Chemically modified *(e.g., heat processing rearrangement of bonding)*	Modified maltodextrins

Table 1. Forms of resistant starch. Adapted from Murphy et al. 2008. Resistant starch intakes in the United States. J. Am. Diet. Assoc. 108: 67-78.

Starch digestibility

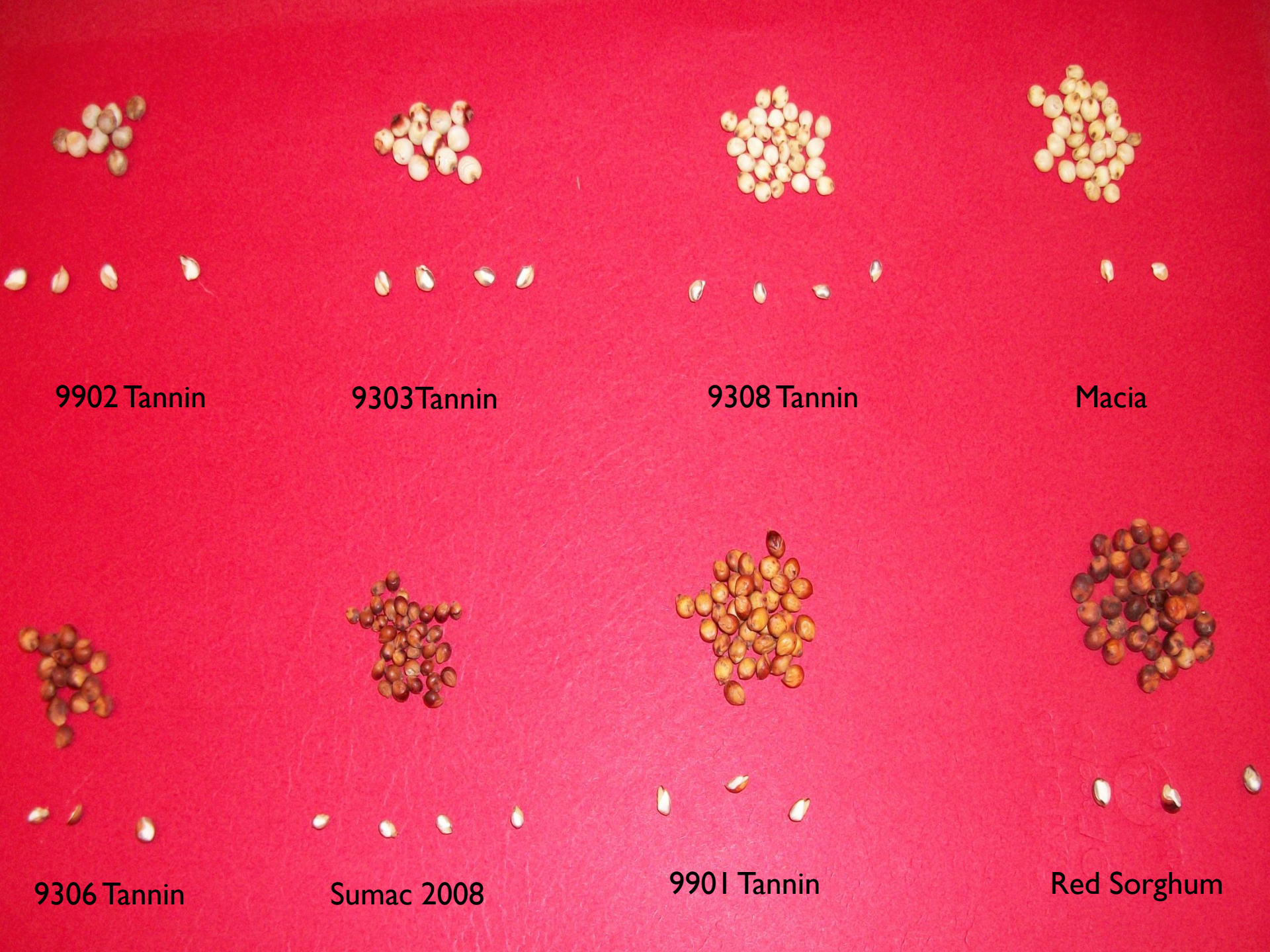
- **OBJECTIVE**
- **To assess the digestibility of starches and flours obtained from tannin containing grain sorghum**
  - **Correlate [Tannin] to starch digestibility levels of flours and starches**

- **HYPOTHESIS**
  - **Condensed tannins will complex with starch and therefore reduce the starch digestibility leading to an increase in SDS and RS and decrease RDS.**

Sorghum Samples

- Harvested in the year 2003 and 2004
- 9301 / 9901 - Shanqui Red
- 9303 - Ajabsido
- 9902 - Koro Kollo
- 9304 / 9904 - IS 8525
- 9305 / 9905 - Sumac
- 9306 / 9906 - SC103 – 12E
- 9308 - Russian Hi starch
- 9907 - SC 599

- Red sorghum (PI 597981)
- Macia – White sorghum
- Sumac 2008


9902 Tannin
9303Tannin
9308 Tannin
Macia
9306 Tannin
Sumac 2008
9901 Tannin
Red Sorghum


RED SORGHUM


9303 TANNINS


MACIA


SUMAC 2008

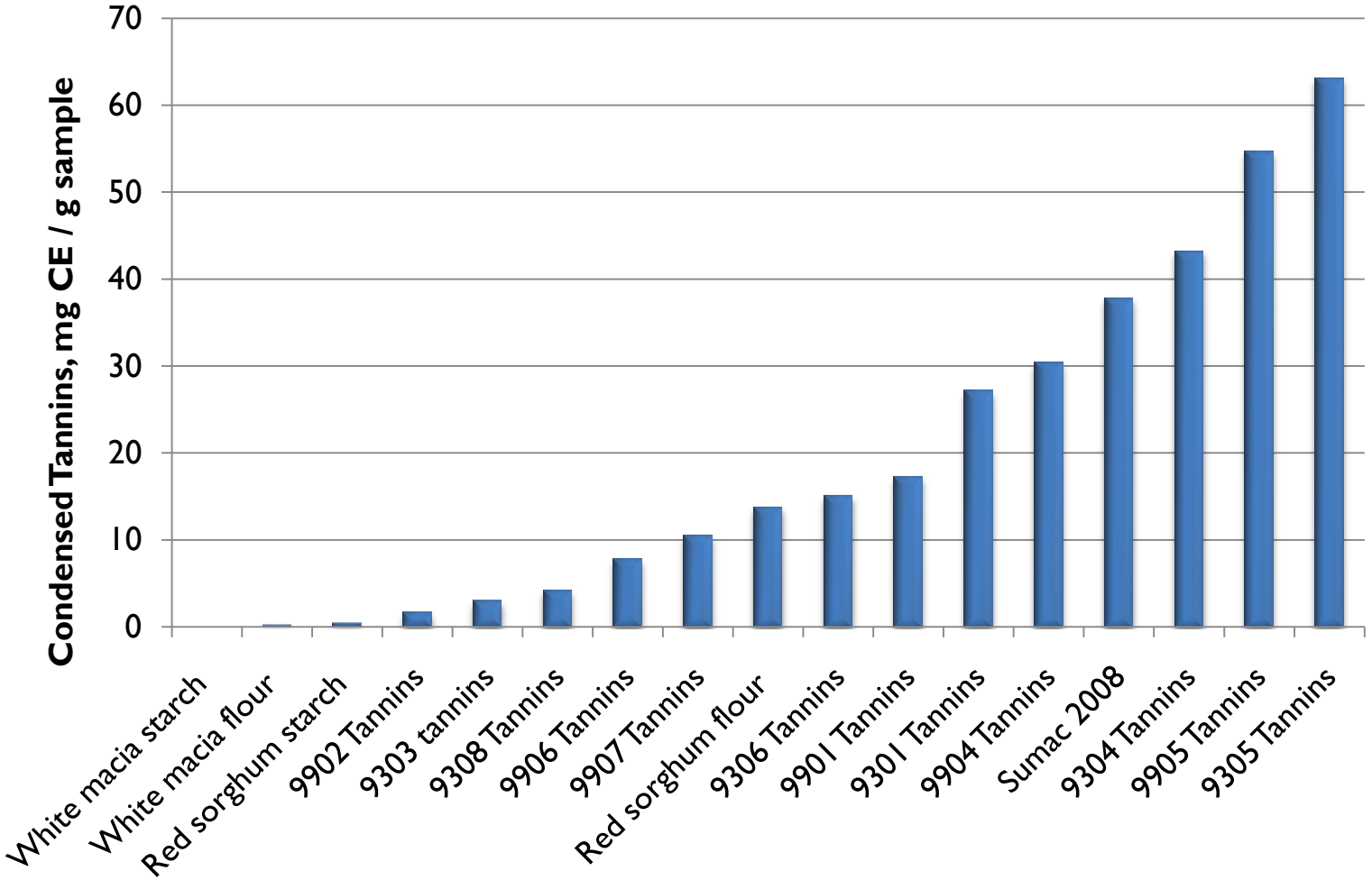
Approaches to Objective 1

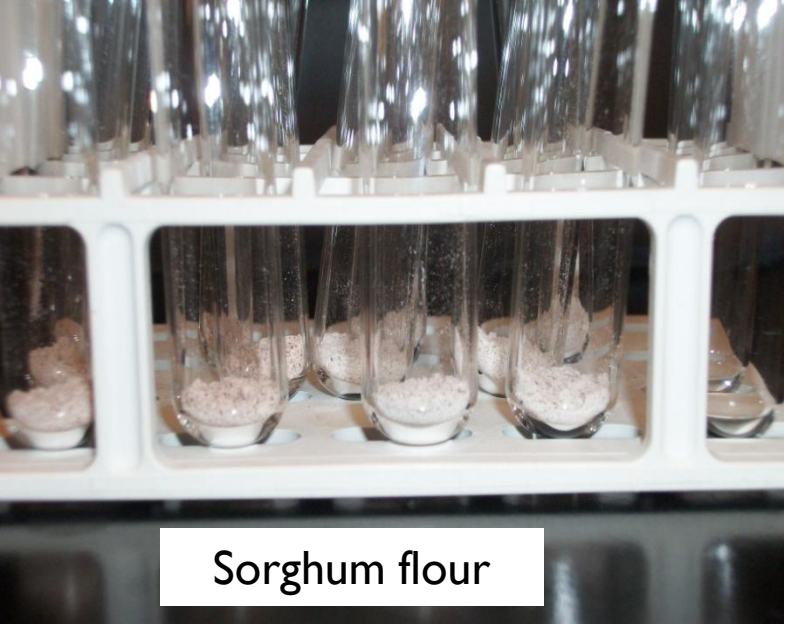
- **Determination of starch digestibility in sorghum flours and their isolated starches**
- **Methods used**
  - **Modified Englyst method**
  - **Proximate analysis: Moisture, Ash, Total starch,**
  - **Vanillin – HCl for quantification of Condensed Tannins (CTs)**
  - **Other tests: Color, Bleach test**
- **Starch isolation by table method**

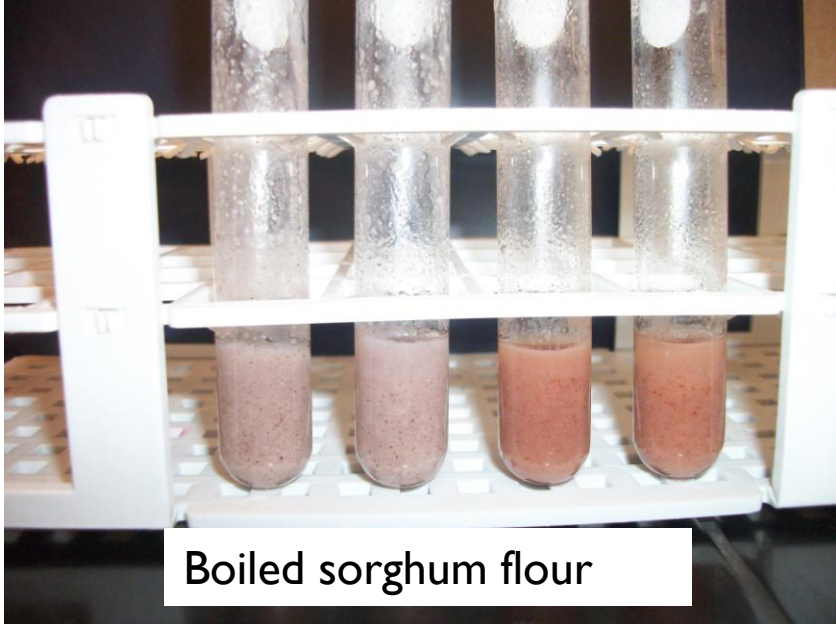
Englyst et al, 1999; Xie and Seib, 2000; Eckhoff et al, 1993; Weller et al, 1988

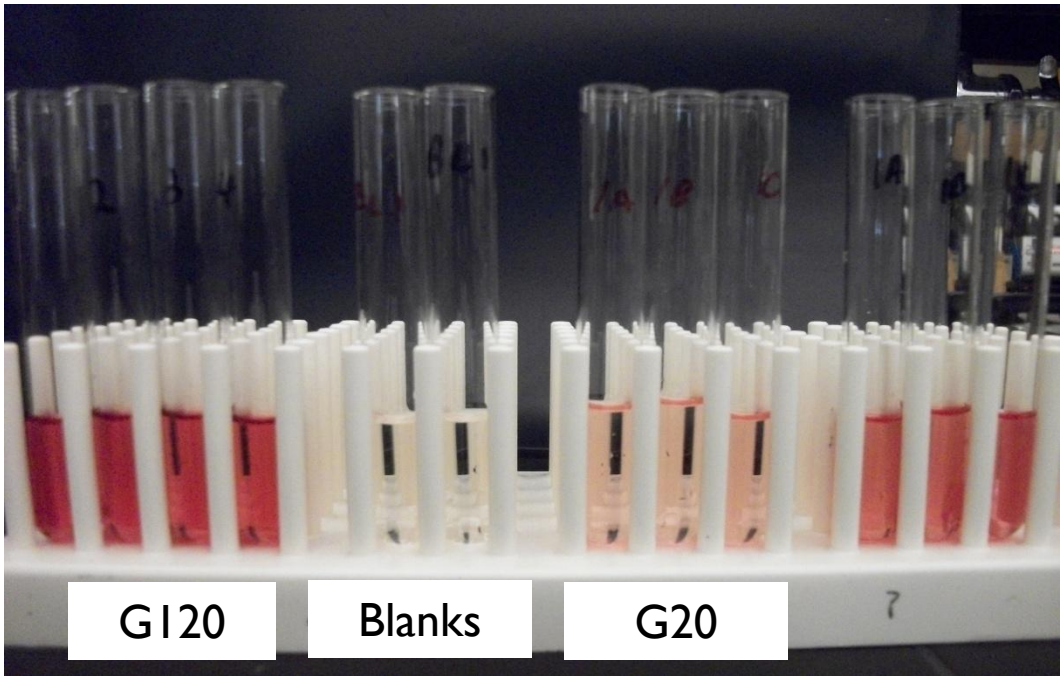
Relationship of Starch Digestibility and Tannin Contents in Sorghum

Condensed Tannins in Sorghum starches and flours



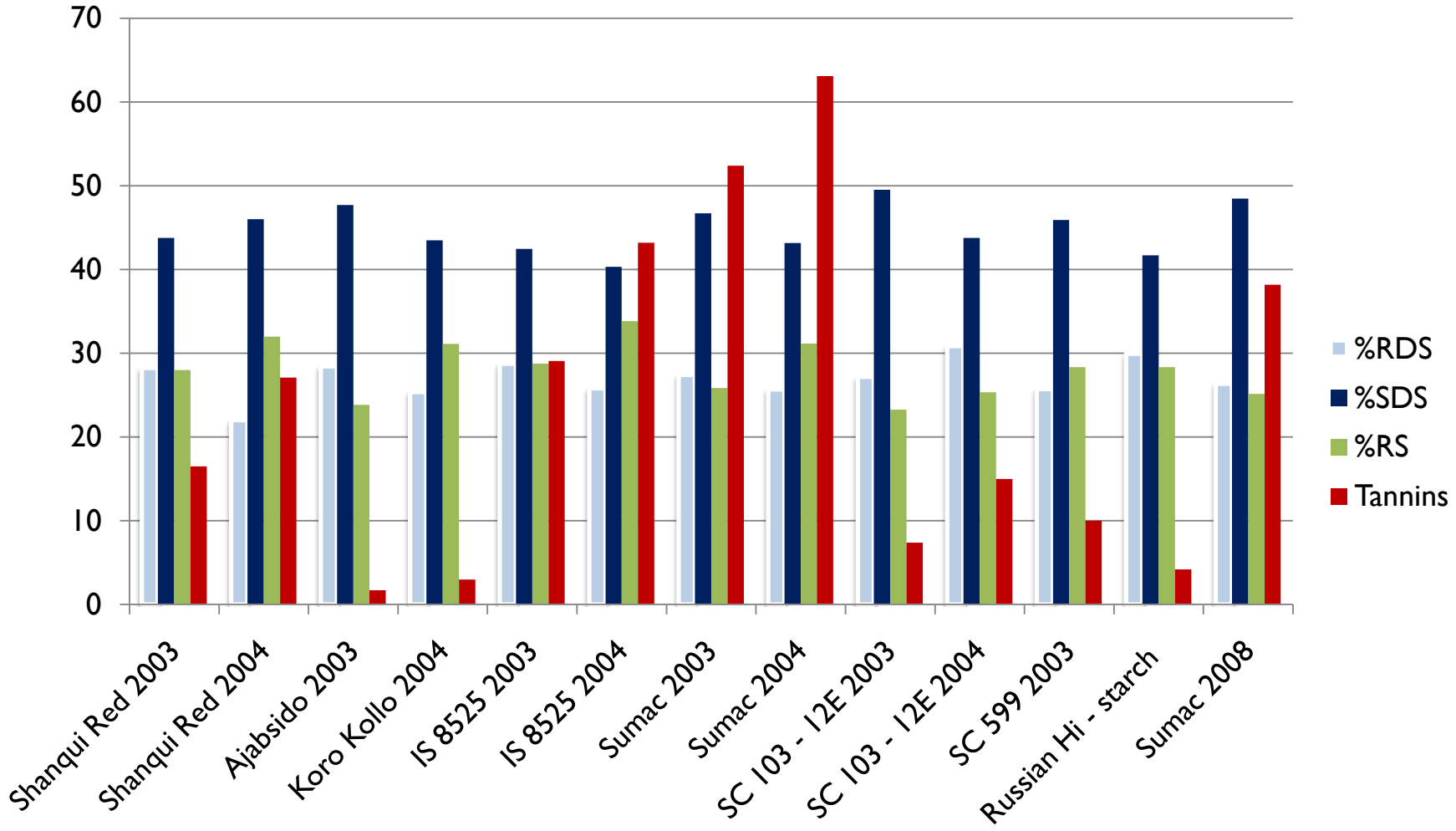

Sorghum flour

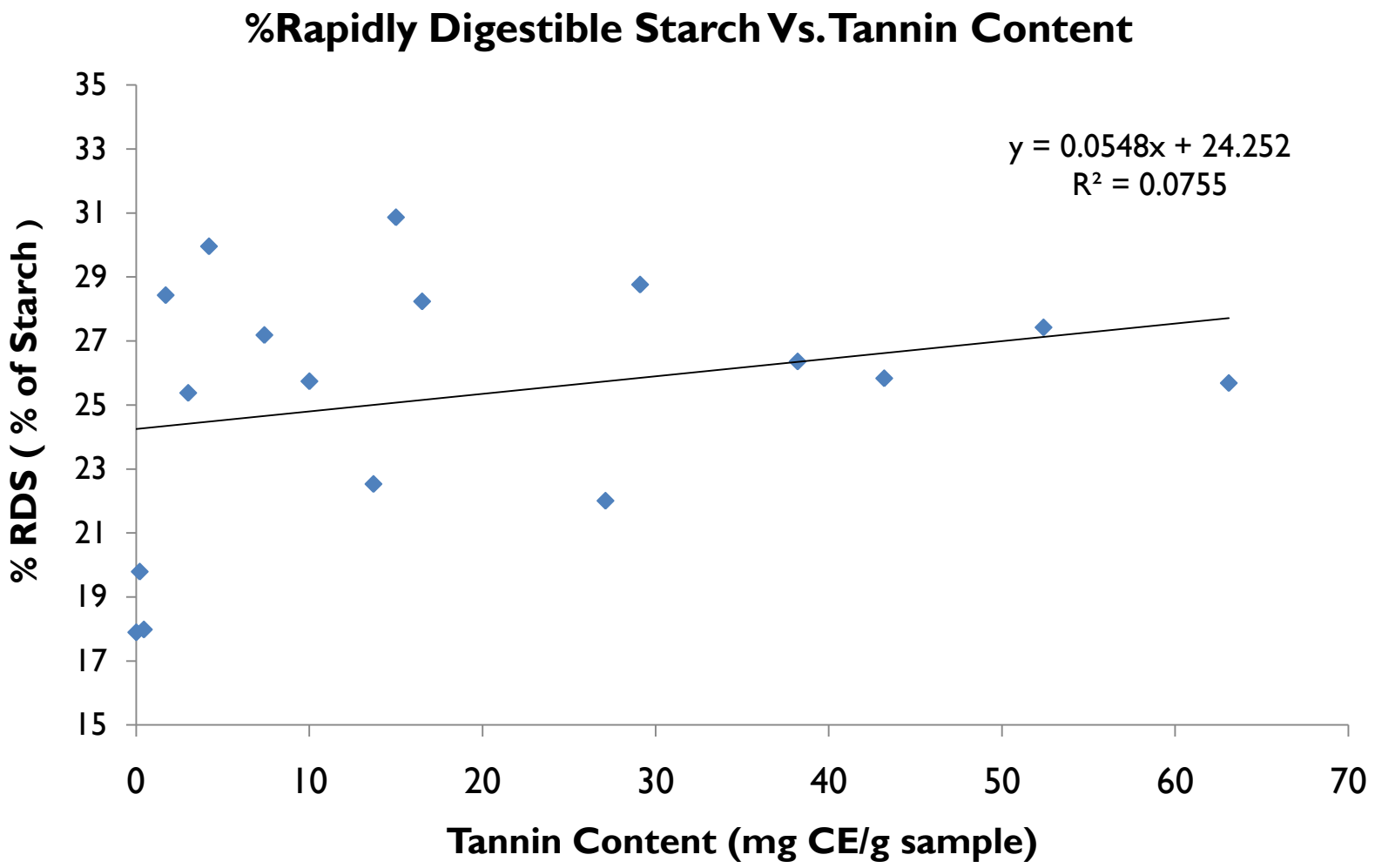

Boiled sorghum flour


G120
Blanks
G20


POWER

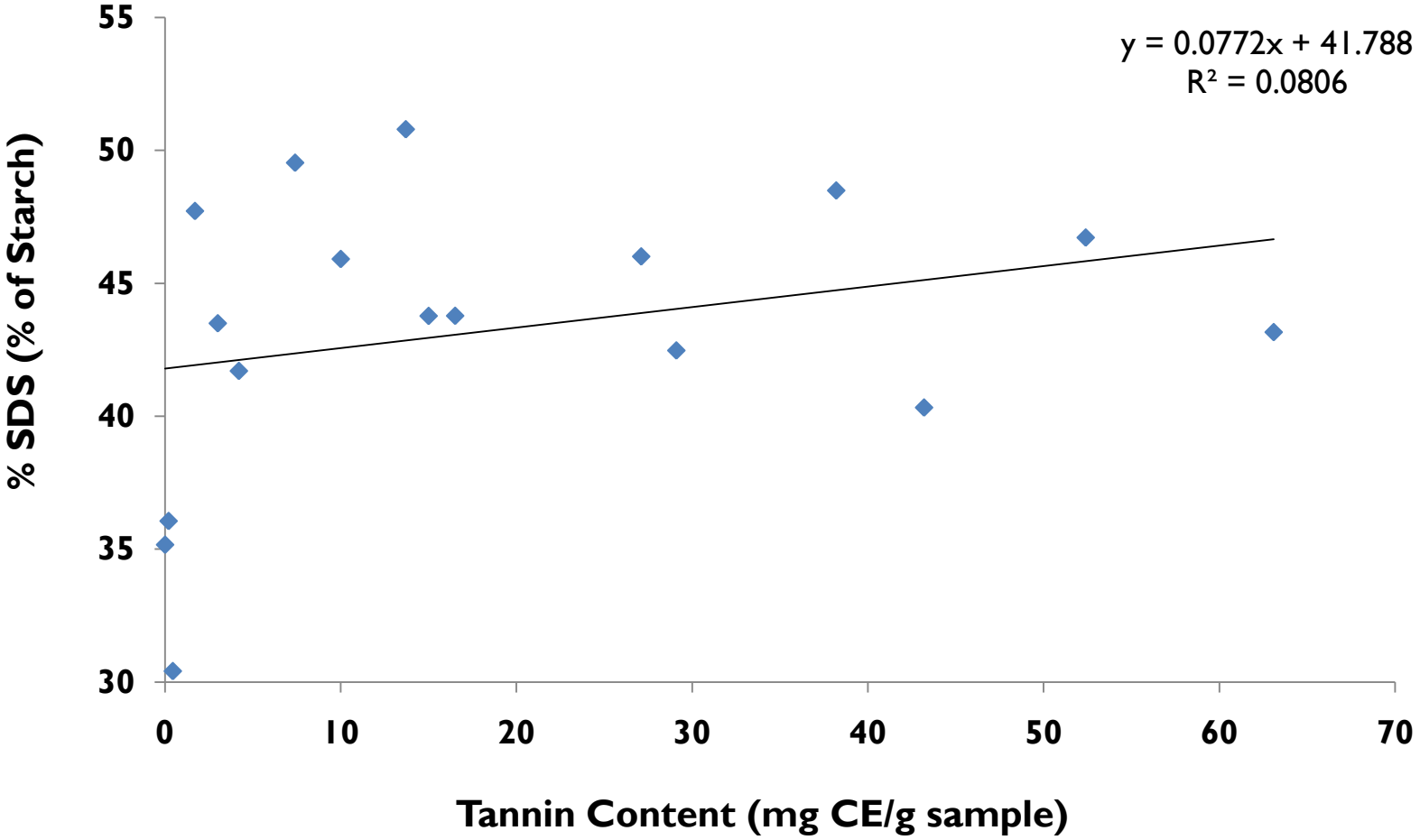
Tannin content vs. Starch digestibility



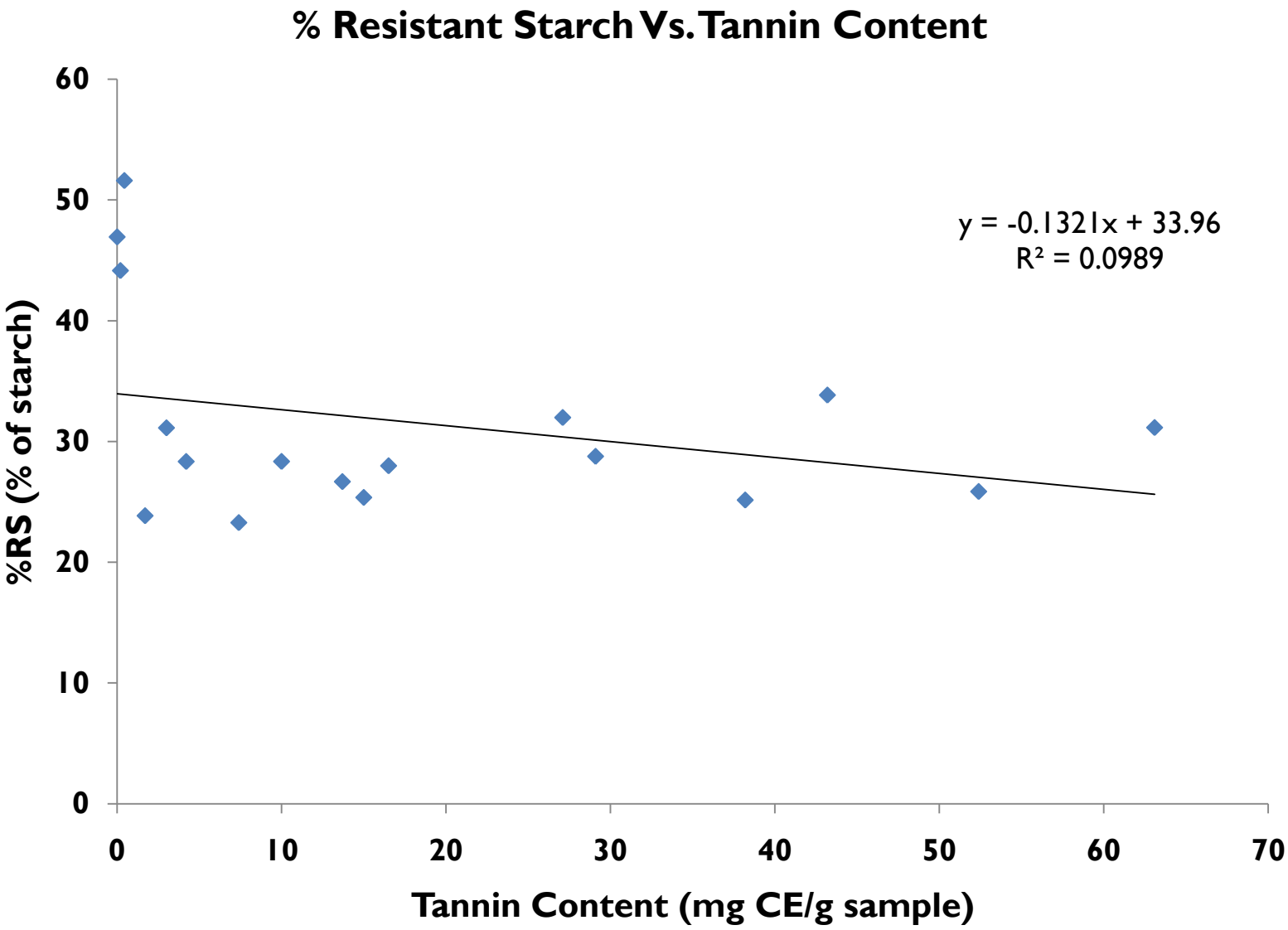


Relationship between Tannin content and RDS; P = 0.4438; P > 0.05

%Slowly Digestible Starch Vs. Tannin Content



Relationship between Tannin content and SDS; P = 0.4159; P > 0.05



Relationship between Tannin content and RS; P = 0.3623; P > 0.05

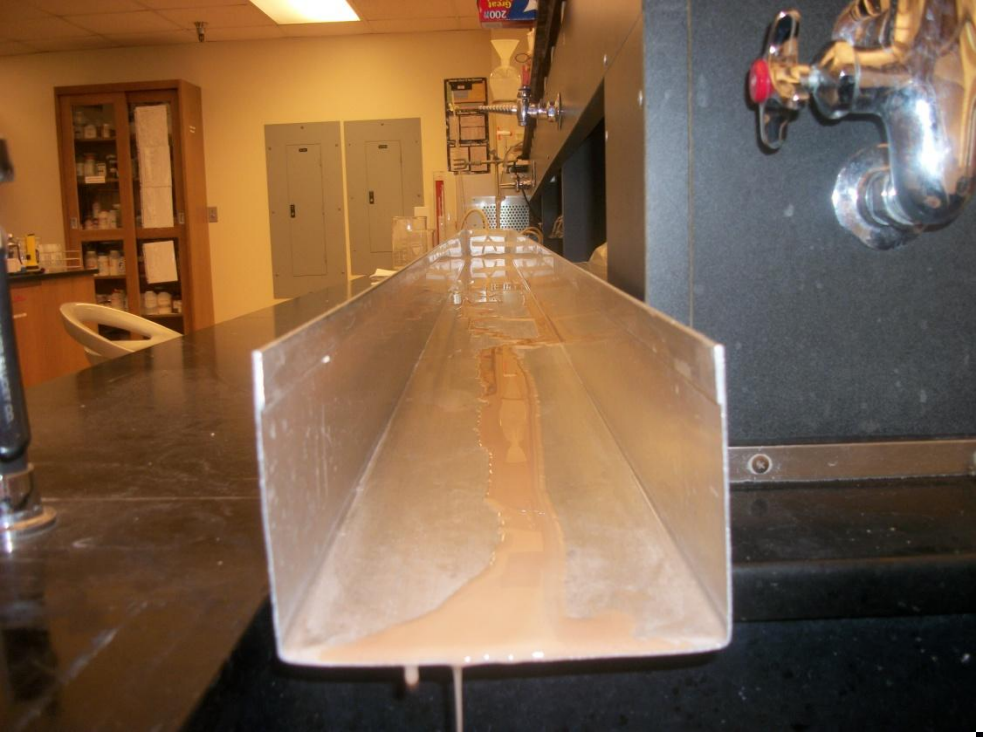
Conclusion

- **No significant correlation between tannin content and starch digestibility**

BUT

- **Sorghum containing tannins exhibited low starch digestibility overall**
- **Grains with low RDS and high SDS and RS are desirable**

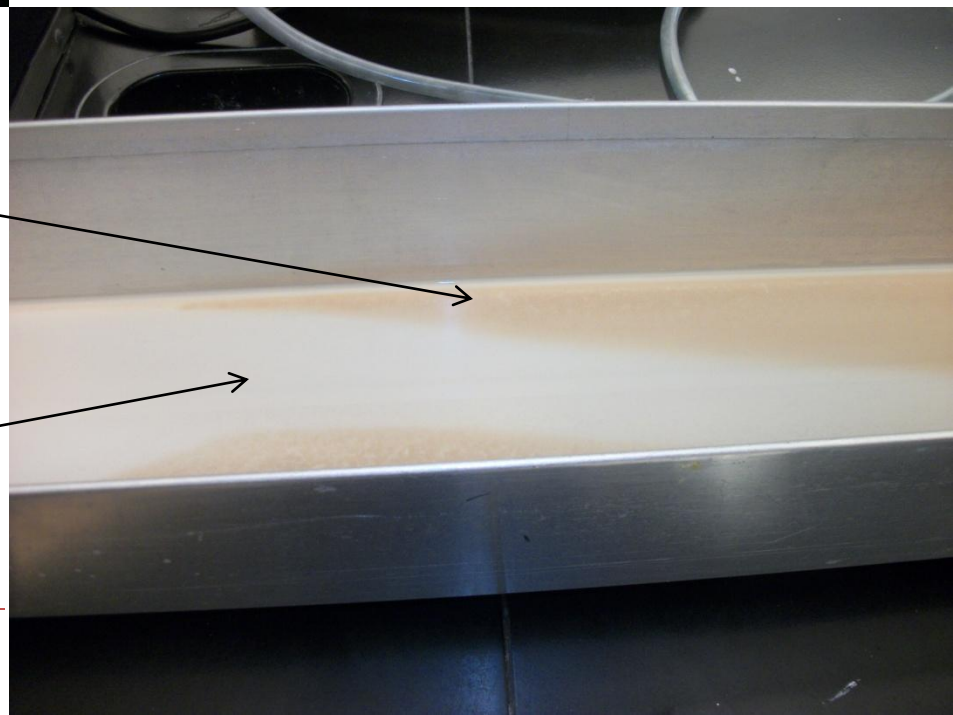
Digestibility of pure isolated starches



Starch isolation from red sorghum

Brown liquid draining out

Starch separating from brown liquid



Starch isolated by wet milling from Sumac grain sorghum

Condensed Tannins isolated from Sumac grain sorghum

Starch Isolation results

Method used – starch table method
Sorghum used: Red and Macia Sorghums

Parameter	Macia sorghum	Red Sorghum
Moisture Content (%)	9.4	9.5
Ash Content (%)	0.1	0.1
Color L a b	 99.9±0.04 -0.95±0.06 0.73±0.04	 97.65±0.18 0.23±0.02 1.72±0.02
Condensed tannins (mg CE /g sample)	-	0.4
Total Starch Content (mg sample / g sample)	810.5	825.2

Levels of digestibility in different cereal starches

Pure Starch	% RDS	% SDS	% RS	Tannin Content (mg CE / g sample)
Red Sorghum**	18.0 ±1.15	30.4 ± 4.79	51.6 ± 4.56	0.44
Macia (white)** Sorghum	17.9 ± 1.09	35.2 ± 5.7	46.9 ± 4.4	-
Normal Maize*	84.7 ± 0.62	8.3 ± 1.85	6.9 ± 1.23	
Waxy Maize*	88.5 ± 3.39	6.6 ± 1.23	4.9 ±2.15	
Rice*	88.0 ±2.16	8.1 ± 4.62	3.9 ±2.46	
Wheat*	81.3 ± 3.70	13.1 ± 2.47	5.6 ± 1.23	
Potato*	83.4 ± 2.46	11.6 ± 4.62	4.9 ±2.15	

*Commercially isolated starch; ** Laboratory Isolated starch
(From Zhang et al, 2008)

Physical and Chemical Characteristics

Physical /Chemical characteristics	Macia Sorghum	Red Sorghum	Sumac
Test weight - kg/m^3 (lb/bu)	1400.0 (108.8)	886.8 (67.3)	1386.1(107.7)
True Density g/cm^3	0.86	1.21	0.83
TKW(g)	28.4	40.6	16.9
TADD (% weight removed)	30.8	57.2	27.8
Pigmented testa	No	Yes	Yes
Condensed Tannins (mg CE/g sample)	0.2	13.74	37.72
Total Starch of flour (mg starch/g sample)	665.2	620.2	610.0
Ash (%)	1.3	1.51	-

Conclusion

- **Sorghum has a potential application in food industry as a low glycemic index starch – Healthy option**
- **Could be used as starch source in diets of individuals sensitive to wheat gluten**
- **Ongoing research**

Some References

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